DAM SAFETY INSPECTION REPORT

OTSEGO DAM
ID #00619
SW 1/4 SEC 17. T1N, R12W
KALAMAZOO RIVER
ALLEGAN COUNTY

OWNER: Michigan Department of Natural Resources

OPERATOR: Tyson Edwards
Allegan State Game Area
4590 118th Avenue
Allegan, Michigan

HAZARD POTENTIAL CLASSIFICATION: High

INSPECTED BY: Michael W. Oakland, P.E.
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Detroit, Michigan

INSPECTION DATE: April 16, 2004

REPORT DATE: July 12, 2004

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INTRODUCTION

This report summarizes the results of a visual inspection of the Otsego Dam on the Kalamazoo River in Otsego, Michigan (Figure 1). The dam is being inspected as required by the Dam Safety regulations that stipulate high hazard potential dams be inspected every 3 years or 3 years following significant repairs. Repairs were made on the Otsego dam during the winter and spring of 2001 to temporarily stabilize the dam in anticipation that PCB contaminated sediments would be removed within 5 years allowing the complete removal of the dam. No substantial progress has been made with respect to the removal of the sediments, and thus, for purposes of this report, it is assumed that the dam must meet the requirements of Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, 1994 PA 451. This report is limited to a visual investigation and review of previous inspection reports, plans, and data which are available. This report should not be considered as an in depth engineering investigation.

The visual inspection was made by Michael Oakland, Stephen Amrein and Todd King of Camp Dresser & McKee. Paul Bucholtz (Michigan Department of Environmental Quality), James Hayes (Dam Safety Unit for the Michigan Department of Environmental Quality) and John Lerg, Scott Hanshue, Tyson Edwards and Sara Schaefer (Department of Natural Resources) were also present. Conditions during the time of the visit were sunny with temperatures around 60 degrees Fahrenheit. The water level at the dam was relatively low with about 6 inches of water flowing over the spillway. The flow of water obscured the spillway surface and downstream apron.

CONCLUSIONS AND RECOMMENDATIONS

The Otsego Dam is in very poor condition and has inadequate spillway capacity. Sinkholes continue to form along the left and right training walls of the spillway indicating severe seepage along the outside of the walls. The seepage is confirmed by water exiting the walls on the downstream side of the spillway (see site sketches and photographs, Appendices A and B, respectively). Previous undermining compromised the foundation piles on the downstream end of the training walls to the point that a portion of the wall on each side had to be replaced with a temporary sheet pile wall and it is believed that this process is continuing on the upstream portions of the dam. In addition, the lower downstream apron of the spillway is cracked and sections of the apron have recently broken off. It appears that the pile foundation support below the apron is also deteriorating. In addition, both the left and right embankments are overgrown in areas and have signs of erosion in several locations due to overtopping or excessive foot traffic. The dam has inadequate slope protection on the upstream face. The concrete continues to deteriorate in the areas where rough surfaces from the former partial demolition are exposed. Failure of the dam would have potential

severe environmental impacts as contamination currently isolated in impoundment sediments would be mobilized and transported downstream.

If the Otsego Dam is not to be removed in the very near future, the following recommended repairs should be completed as soon as possible. These repairs are listed by priority.

- Reconstruct the entire spillway structure, replacing the walls, slab and fixed crest weir on a new foundation. As part of the reconstruction, the new spillway should be enlarged to meet the currently capacity requirements for the design storm.

- The entire left and right embankments should be re-graded, removing all trees and brush, and shaped with an even crest with upstream and downstream slopes no steeper than 3 horizontal to 1 vertical. Debris below the former powerhouse location should be excavated and replaced with low permeability fill which extend into the abutment to form an adequate cutoff to seepage and to avoid loss of ground into the penstocks and basement of the former structure. The upstream slope of the re-graded spillway should be protected by riprap with grass planted over the remainder of the spillway.

PROJECT INFORMATION SECTION

Otsego Dam was constructed in 1903-1904 as part of a hydroelectric facility. A downstream, pile-supported, reinforced concrete apron was added to the dam's spillway around 1917. The powerhouse was rebuilt and new generators were installed in 1925 but it is not known if other work was performed on the dam during this period. In 1965, the generators were removed from the facility and ownership of the dam was transferred from Consumers Power Company to the Michigan Department of Natural Resources (DNR). The DNR raised and jammed the spillway control gates in the open position in 1970 to lower the upstream impoundment to the fixed weir level. The records on the dam are not clear on whether the spillway control gates and support members, spillway catwalk, and powerhouse were removed during a military training exercise around 1975 or whether the work was performed along with re-grading by a contractor around 1985.

The dam is approximately 700 feet long. Looking downstream, the dam is comprised of a left earthen section, a concrete service spillway, a center earthen section, a former concrete hydroelectric generation section, and a right earthen section. The section lengths are approximately 170, 128, 135, 110, and 157 feet long respectively. The elevation datum used on the 1903 design plans is unknown but the local datum of elevation (El.) 90 is around 690 feet above the National Geodetic Vertical Datum. Elevations mentioned in this report will be those used on the original design plans.

The design plans show the earth embankment sections to have a crest at elevation (El.) 88.00. The crest width is 16 feet for the right and center embankments and 20 feet for the left embankment. The upstream slope of the embankment is 2.5:1 while the downstream slope is 2:1. An 18 feet high

plain concrete core wall extends along the earthen sections parallel to and approximately 16.5 feet upstream from the centerline of the embankment. The base of the concrete core wall is at El. 69.00 with six inch timber sheeting extending the cut off down to about El. 53.00.

The service spillway has a clear opening of 118 feet. It was originally divided into five 20 feet wide bays with 4.5 feet wide buttresses between each bay. The concrete buttresses had a top elevation of 87.17 and extended from 2.5 feet in front of the spillway foundation to 18 inches downstream of the front face of the sill. Both the front and rear end of the buttresses were beveled to form 2.5 and 3 feet points, respectively. The buttresses have been removed down to or below the level of the weir. The downstream portion of the buttresses has been removed to a level where they are no longer visible above a one foot depth of water. Each of the five bays had a 12.5 feet high taintor gate which sealed against the top of a 3.5 feet wide broad crested weir. The weir has sloping upstream and downstream faces. The top of the weir is at El. 71.80. It has a base width of 10.5 feet and is monolithic with 18 feet downstream plain concrete apron. The top of the apron is at El. 69.00. A 6 inch high, 2 feet wide concrete sill starts 11.75 feet from the weir. Oak piles on a 5 feet spacing along the centerline of the spillway and approximately 7 feet spacing along the centerline of the dam supported the weir and apron. Two piles in each of the last three rows in each bay were allowed to project 2.8 feet above the apron, apparently to serve as baffle blocks. The projecting portion of the piles have been removed or worn away as they are not visible in one foot of water. Six inch timber sheet piling, approximately 16 feet deep, was to be constructed at the upstream face of the weir and a similar sheet pile cutoff wall 26 feet deep was planned 3.5 feet upstream from the end of the apron.

A pile supported timber grid, fastened to a timber embedded in the apron just behind the sill, extended approximately 24 feet at the level of the apron and approximately another 24 feet at a 14 inch lower level. Plans indicate the upper timber grid was replaced around 1917 with a 23.5 feet long reinforced concrete apron extension supported on the original timber grid piles. There are also indications that the lower timber grid has also been replaced with a concrete apron but this has not been confirmed.

The spillway concrete side walls (called abutment walls herein to be consistent with previous inspection reports) are approximately 100 feet in length. They extend approximately 25 feet upstream of the weir and 70 feet downstream of the original spillway apron. The upstream and downstream walls are supported by a single pile line with piles approximately 6 feet on center. The wall at the weir and apron section is supported by a twin line of piles with the piles approximately 5 feet on center. A 6-inch sheet pile cutoff is connected to the spillway upstream cutoff wall and extends to the downstream end of the side walls. The length of the sheeting is 18 feet between the spillway cutoff walls and 24 feet downstream of the spillway downstream cutoff wall. The design plans do not show a connection of the left embankment cutoff wall to the spillway and spillway abutment wall cutoff sheeting. The abutment walls were removed to approximate El. 76 in 1985.

The hydroelectric generating section of the dam has a length of 98 feet between side walls and a width of approximately 33 feet. A concrete gravity dike was constructed along the upstream face of the section with a top at approximately El. 68.42. Timber cutoff walls were present at the upstream and downstream faces of the section. The structure and dike were supported by oak piles. A generator building was adjacent to the section on the center embankment. Pile supported plain concrete training walls extending upstream and downstream were present at each end of the hydroelectric generating section. The center and downstream portion of the walls had timber cutoff walls beneath them. The original design plans do not show definite connections between the various cutoff walls. The superstructures of these units have been removed above El. 76.4 and the debris used to fill the lower portions of the structure and to create a 2:1 upstream slope to the area and a 1.5:1 downstream slope turning the section into a quasi-rubble filled dam.

PRIOR INSPECTIONS

Since the 1986 demolition, the dam has been inspected on or about a three year cycle by the Michigan Department of Environmental Quality (MDEQ) Dam Safety Unit and the Wildlife Division Staff of DNR. The inspections occurred in 1990, 1993 and 1996. The 1996 inspection report and the letter dated November 2, 1998 by MDEQ contained the following observations:

- The downstream end of the spillway left abutment wall and a portion of the apron are undermined for approximately 25 feet exposing the wooden foundation piles.

- The spillway left abutment wall contains a vertical crack approximately 25 feet upstream of the end the wall. The crack has a slight separation but indicates no differential movement.

- The junction of the above wall and the spillway apron is severely cracked. Flow through this crack is scouring away the earth around the wall foundation piles and under the apron. An eleven foot tree limb was inserted under the apron during the inspection. It was noted that the apron is also founded on wooden piles which are partially exposed.

- The spillway right abutment wall contains an open vertical crack approximately 25 feet upstream of the end the wall. The crack is separated about 3 inches with the downstream portion about 2 inches higher and 2 inches inward of the upstream portion of the wall. It was noted that most of the movement occurred prior to 1990. Between October 1995 and May 1996 about 1/4 inch of additional movement has been observed at the crack.

- Due to high tailwater conditions, the degree of undermining of the downstream end of the spillway right abutment wall could not be determined.

- Erosion gullies caused by flood overtopping of the cut back embankment slopes areas are present at the spillway abutments.

- Sinkholes are present along the spillway abutments. Sink holes were found during the 1990 inspection and filled in 1991. They reappeared before the 1993 inspection.

- No evidence of seepage was found on the embankment slopes or downstream toe.

- Minor seepage is present at cracks in the downstream face of the powerhouse foundation.

- Cut brush and trees have been left on the embankments.

The general condition of the dam was assessed to be poor. The undermining of the left downstream abutment wall, the recurring sinkholes, and the associated leakage were deemed to pose a serious threat to the stability of the dam.

The dam was inspected again in November 1998 by CDM for purposes of assessing interim repairs required to maintain the stability of the dam over the next 5 to 10 years during removal of PCB contaminated sediments upstream of the dam to allow for the dam removal. The inspection recommended that the cracked and displaced lower sections of the spillway training walls be removed and replaced with temporary steel sheet pile walls, to remove some of the existing brush on the dam and to fill sinkholes as they appear.

In addition, to enhance dam stability beyond the next five years, jet grout stabilization of the soils behind the training walls was also recommended. The grout would cut off flow behind the walls which is causing the sinkholes and stabilize the soils. The grout stabilization recommendation was not incorporated as it was believed that the dams would be removed within a five to ten year time-frame. The remaining recommendations were implemented and this work was completed in spring of 2001. Periodic inspections approximately every 6 months have been conducted since that time to assess the interim condition of the dams.

FIELD INSPECTION

Observations at the time of the site visit are summarized as follows:

- In general, the right embankment is very uneven with a low area at the former powerhouse, rising to a high area in the vicinity of the former island and then dropping back down to a cut slope adjacent to the right training wall of the spillway. The embankment generally appears to be stable, other than sloughing on the upstream slope near the training wall. The wide embankment on the left side appears to be stable with no signs of movement or sloughing. The temporary sheet pile walls continue to appear to be in good condition with no signs of movement.

- Slight movement of the left training wall is believed to have occurred based on a small, recent, slight separation between the wall and the grout backfill placed around the wall at the time of the 2001 repairs.

- The training walls are spalled in numerous locations and the upstream end of the right training walls is eroded to a depth of about 1-1/2 inches at the normal water level.

- Sinkholes continue to form along the back side of both the left and right training walls. The sinkholes have grown in size substantially since the last visit indicating increasing seepage below or behind the walls and continued failure of the cutoff walls below the dam.

- Cracks in the soil, near the downstream end of the left training wall, indicate a scarp forming all the way to the ground surface over the voids created from the internal seepage erosion.

- Seepage through the wall on both the left and right sides confirm the flow of water behind the walls.

- A crack previously observed in the middle of the lower apron appears to have grown. The crack, which can only be seen during very low flow conditions, seems to have increased from about ½-inch in width to about 1-1/2 inches in width near the left training wall. A section of the apron about 4 square feet in area is missing from the downstream right corner of the lower apron.

- The left and right embankments of the dam both have areas overgrown by brush, trees and large stumps on the upstream slopes. A portion of the downstream slope on the left embankment is also heavily overgrown with brush and trees.

- The upstream slope of the embankment near the right training wall is eroded at the toe and water is entering the embankment from behind the training wall though the demolition debris at the upstream face.

- Neither embankment has adequate erosion protection on the upstream slopes.

- At least one rodent hole was found on the right embankment and two on the left embankment.

- The area around the former powerhouse is low and continues to be an area overtopped during storm events. While not leaking at the time of this visit, recent visits during higher pool conditions have shown slight leakage through the embankment at the former powerhouse location. Continuing uncontrolled leakage could cause internal erosion of the embankment, ultimately leading to dam failure.

It was not possible to confirm the condition of the downstream apron, stream bed below the apron or spillway buttresses. It is reported that a large plunge pool exists downstream of the dam and may be contributing to lateral movement, causing the cracking of the downstream apron.

STRUCTURAL STABILITY

Given the condition of the visible piles at the spillway, it should be assumed that the existing spillway does not have adequate stability to meet current dam safety requirements. In particular, it appears that the lower apron is extremely vulnerable at this point. However, loss of the apron is not believed to pose an immediate threat to the dam, although rapid action would be required at that time to prevent the full loss of the structure.

Continued erosion due to seepage/flow behind the training walls will continue to result in sinkholes. The ground surface behind the walls should be considered unstable. People should be restricted from this area.

Continued deterioration of the concrete forming the piers and training walls, will also result in loss of stability of the spillway structure.

The dam embankments appear to be generally stable with no signs of displacement or sloughing. However, the area of the former powerhouse does overtop during storm events and while no significant erosion is currently visible, long term exposure to this event could cause instability of the embankment.

HYDROLOGY AND HYDRAULICS

The inspection report noted that the design discharge for the spillway is the 0.5 percent chance flood discharge of 13,900 cfs. This would result in a flood stage at about El. 80.75 at the dam which is about 4.3 feet above the top of the spillway abutments and the current embankment grade at the former powerhouse. The capacity of the spillway with a flood stage at the top of the spillway abutment walls is 3,840 cfs which is approximately equal to the estimated annual flood.

Currently, each of the overflow areas has limited erosion protection consisting of vegetation cover, loose riprap and grouted riprap in the downstream area of the area behind the left training wall. This erosion protection is considered to be inadequate for the frequency of the overtoppings. The spillway capacity must be increased to the design storm condition.

OPERATION AND MAINTENANCE

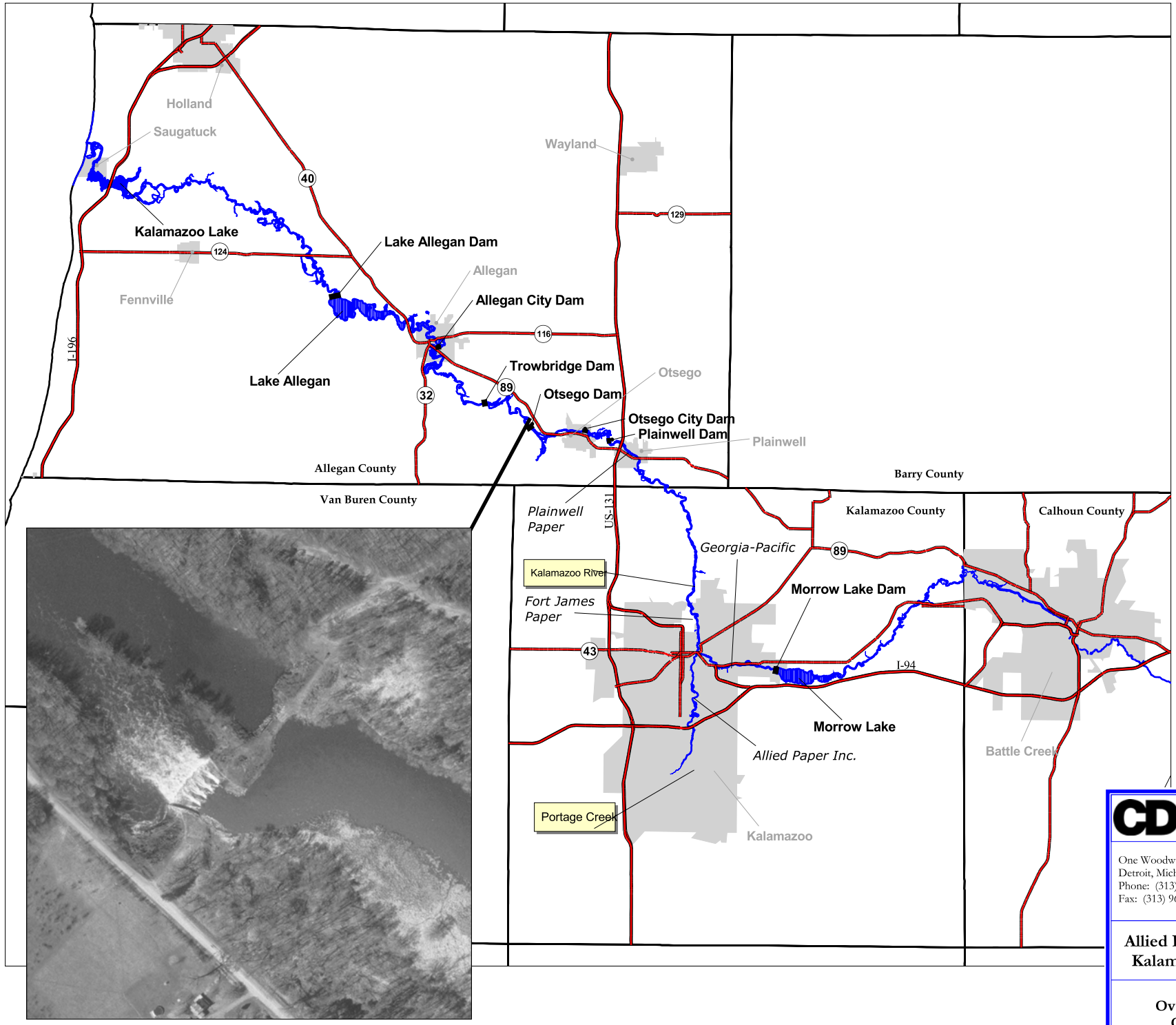
Operation of the dam is by Wildlife Division staff from the Allegan State Game Area. According to MDEQ and MDNR staff, a written operation and maintenance (O&M) plan has been developed for the dam and is on file with the Dam Safety Unit.

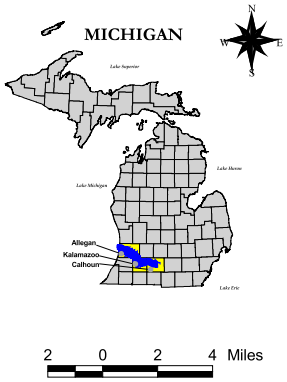
EMERGENCY ACTION PLAN

According to MDEQ and MDNR staff, an emergency action plan (EAP) has been prepared for this facility. A copy is on file with the Dam Safety Unit and with appropriate DNR offices. This EAP should be reviewed annually and updated as necessary.

APPENDIX

A sketch of the observations made at the time of the visit (Appendix A) and photographs from this inspection (Appendix B) are attached.





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Updated:
6/11/04

Allied Paper, Inc./Portage Creek/ Kalamazoo River Superfund Site

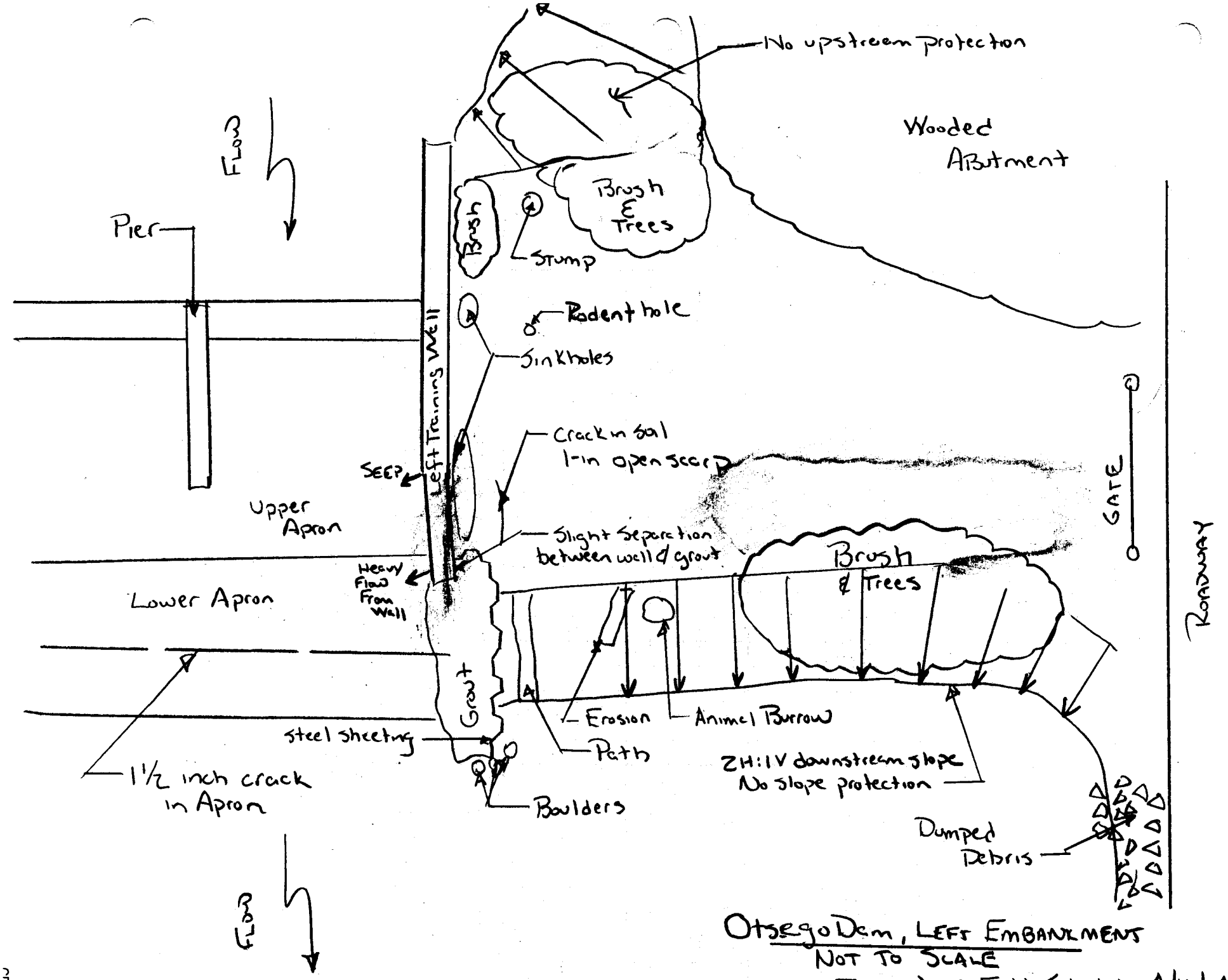
Overall Site Map
Otsego Dam

Figure No. 1

Site Sketches

April 16, 2004

Appendix A



Otsego Dam, Left Embankment
Not To Scale
Inspection Field Sketch 4/16/04

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Otsego Dam, Right Embankment

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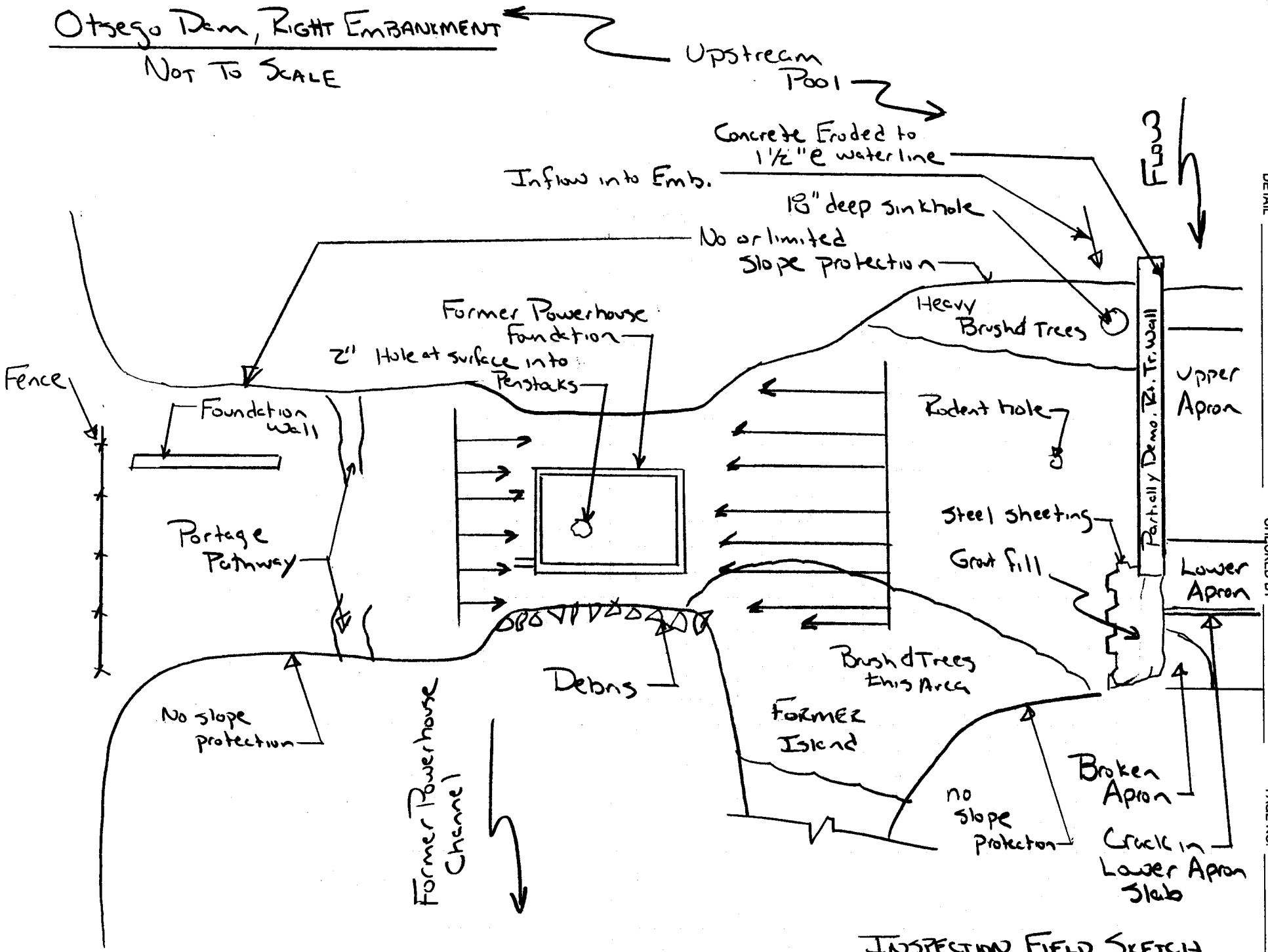

Inspection Field Sketch
4/16/04

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Site Photographs

April 16, 2004

Appendix B

Otsego Dam - Right Side

View of Left Training Wall

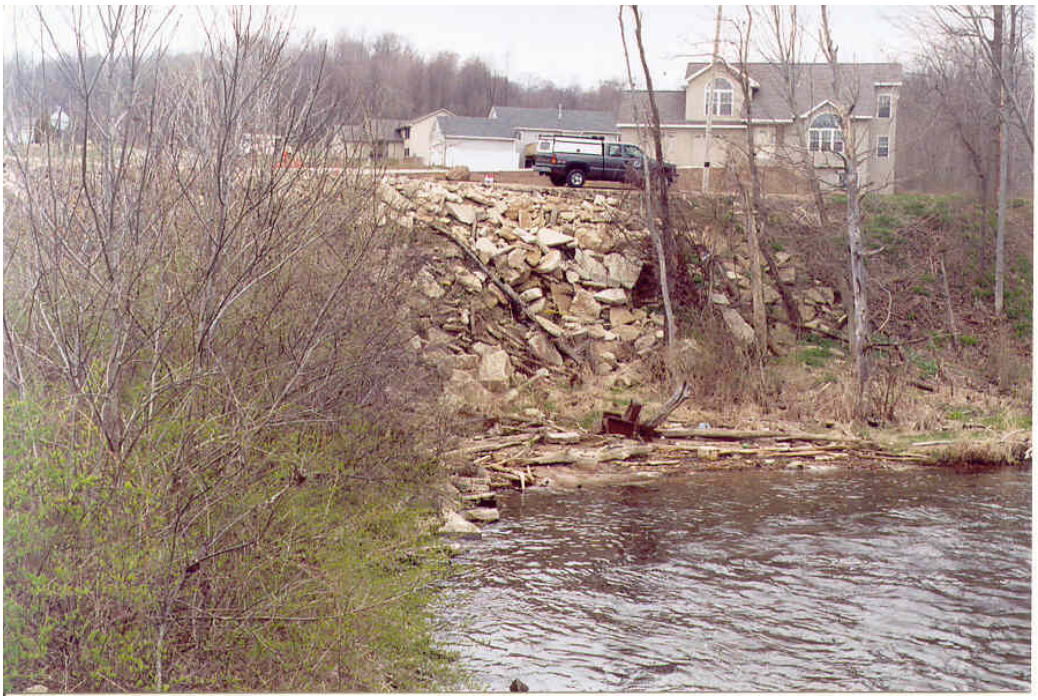
Erosion and Deterioration of Right Training Wall

Otsego Dam - Right Side

Powerhouse Area on Right Embankment

Right Embankment at Former Island

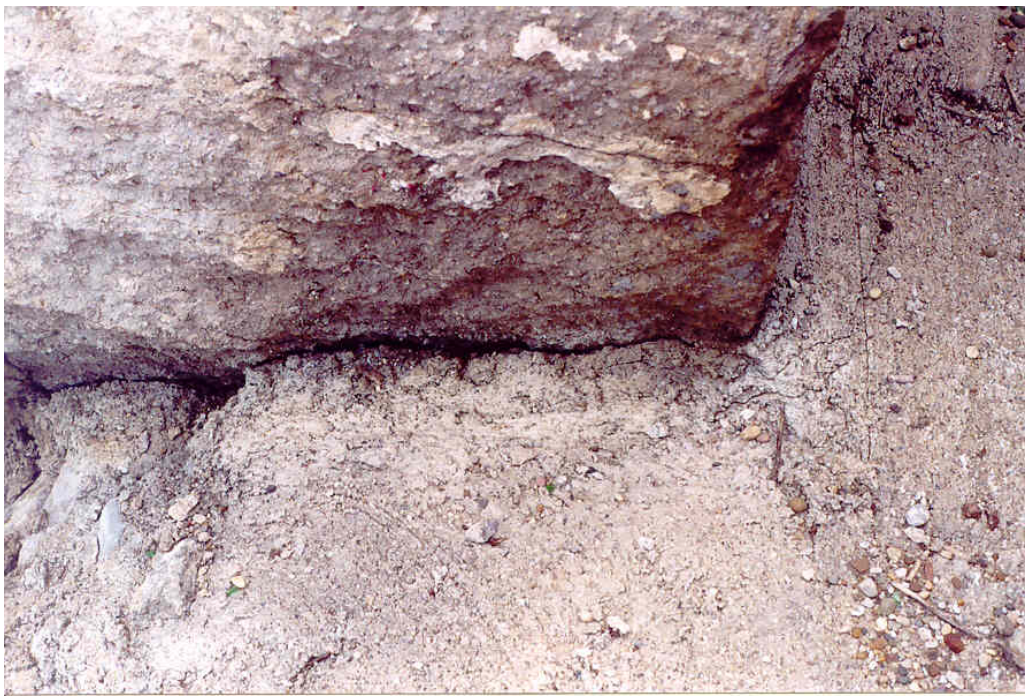
Otsego Dam - Left Side



Rubble on Left Downstream Abutment

Scarp found Next to Sinkhole at Downstream end of Left Training Wall

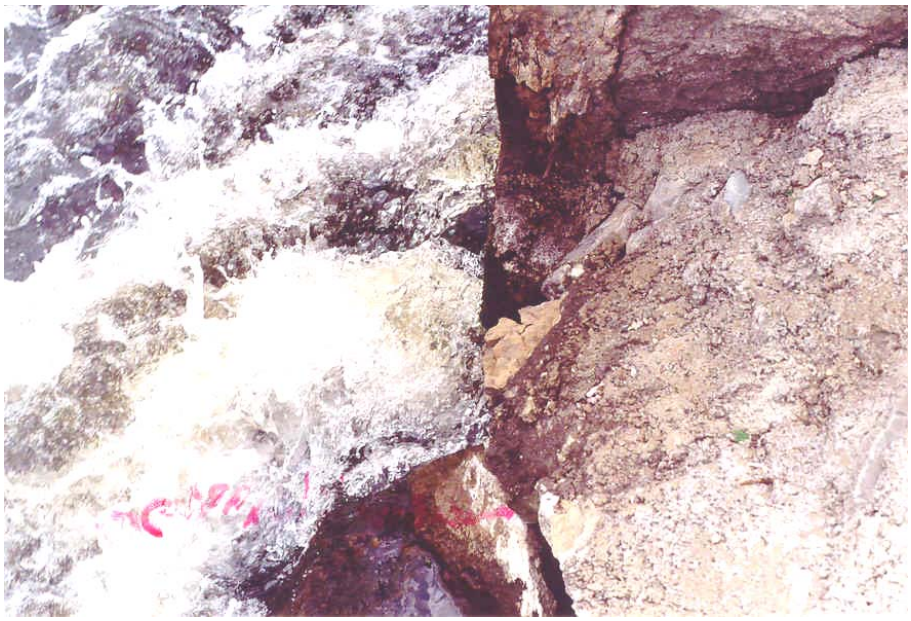
Otsego Dam - Left Side



Crack indicating Wall Movement

View of Right Training Wall

Otsego Dam - Left Side



Outflow of Water from behind Left Training Wall

Sinkhole next to Left Training Wall